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THE VEGETATION OF AUSTRALIA AND NEW ZEALAND

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THOSE parts of the world which for one reason or another are completely isolated show very plainly the effects of this isolation upon the animals and plants which inhabit them. The degree of specialization in these organisms is to a certain extent an index of the length of time the region has been shut off. A comparison of these organisms with those of other regions may throw light upon such problems as the changes in the distribution of land and water upon the earth's surface in the course of ages, and thus be of great interest to the geologist and geographer as well as to the biologist.

If we compare the lands of the northern hemisphere, as they now exist, with the principal land masses of the southern hemisphere, we find the former to be very much more extensive than the latter. In the north there is a marked preponderance of land in the polar and subpolar regions, which merge into the temperate regions in both the American and Eurasian continents. In the southern hemisphere there is an extensive almost absolutely barren polar continent, but the regions corresponding to the subarctic land masses of the north are entirely occupied by water; and the south temperate regions are completely separated from the antarctic continent by a wide stretch of sea.

Moreover, the temperate regions of Australasia, South Africa and South America are widely separated from each other by the Atlantic, Pacific and Indian oceans. In extent the temperate regions of the south are much less than those of the northern hemisphere. As might be expected, this condition of things is accompanied by a much greater diversity in the temperate floras of the southern hemisphere than is the case in northern latitudes. This perhaps reaches its maximum in the Australasian region, the completely isolated Australian continent and the islands of New Zealand having extremely specialized floras which are of very great interest to the student of plant geography.

While Australia and New Zealand are usually grouped together geographically as "Australasia," they differ much from each other in their vegetation, although having more or less in common. New Zealand is separated from Australia by over a thousand miles of sea, and many of the most characteristic Australian types are quite absent, and others only very sparingly represented. Owing to its very much greater size and range of climate, Australia, as might be expected, possesses a much more extensive flora than the relatively small islands of New Zealand.

The completely isolated continent of Australia is almost exactly the size of the continental United States exclusive of Alaska. The Australian climate, however, is very different. The northern portion of Australia is within the tropics, the tip of York Peninsula being only 11 degrees from the equator, while the southernmost part of the continent scarcely touches the fortieth degree of latitude. The adjacent island of Tasmania extends about three degrees further south. The climate is therefore much warmer on the whole than that of the United States or Europe, the coolest regions in the south having a climate comparable to that of California or the Mediterranean. At the north a true tropical climate prevails.

The topography of Australia is much less varied than that of the United States. There are no mountains comparable to our great western ranges, and there is a marked dearth of large rivers and lakes. The principal mountain masses are close to the eastern coast, a succession of mountain ranges and highlands extending from the York Peninsula to eastern Victoria and Tasmania. In Queensland there are some definite mountain ranges, but for the most part the high land is a plateau sloping gradually westward, with more or less definite escarpments toward the east. These escarpments sometimes exhibit abrupt gorges cut by the streams. These are well shown in the Blue Mountains west of Sydney. The highest point in Australia is Mt. Kosciusko, 7,300 feet, situated in New South Wales near the Victoria border.

This highland region and the adjacent coastal areas have for the most part a good rainfall, but there are no large rivers. The heaviest rainfall is in the coastal region of North Queensland where at certain stations it may exceed two hundred inches annually and averages one hundred and fifty.

Inland, however, the rainfall diminishes rapidly, and a third of the continent is said to have ten inches or less annually and another third less than twenty. This means that two thirds of the area of Australia must be classed as desert or semiarid, and much of it unsuited to agriculture, although vast areas are more or less adapted to grazing, which at present in much of the commonwealth is the most important industry. There is a more or less marked wet and dry season in most of Australia, as on our own Pacific coast. In the south most of the rain falls during the winter months, May to September; in the north the heaviest rains fall in the summer. June is the wettest month in the south, January in the north.

Northern Australia, lying entirely within the tropics, has for the most part a genuinely tropical climate, hot and humid in the coastal districts. In the more elevated regions of the plateau, however, there may be sharp frost during the winter months, June to August. In August of last year I observed bananas and other tender plants cut down by frost at an elevation of 2,000 to 3,000 feet, in latitude 17°. On the coast, however, frost is quite unknown, and the forest shows a genuine tropical luxuriance.

The wettest region in Australia is in northeast Queensland, on the coast, about latitude 17°. In this region a short range of precipitous mountains rises directly from the coast to a height of over 5,000 feet, the highest land in the state. At the foot of this range, the precipitation is very heavy. One place, Babinda, which I visited in August, 1921, had already registered over two hundred inches for the year, and it rained almost incessantly during my stay.

The low swampy forest about Babinda was almost impenetrable, the trees loaded down with creepers of various kinds, among which the rattan palms were only too conspicuous. Throughout the eastern tropics the thickets of rattans are a great hindrance to progress in the forest, as their tough, horribly spiny twining stems make absolutely impenetrable tangles, natural barbed-wire barriers. Climbing Aroids and species of Vitis and Piper are also abundant as well as various other lianas.

In these wet lowland jungles, the palms reach their fullest development, forming a conspicuous and beautiful feature of the vegetation. One of the commonest and most attractive species is *Archontophoenix Cunninghamiana,* often cultivated under the name *Seaforthia elegans,* and one of the most beautiful of all palms, with its smooth slender trunk and crown of graceful feathery leaves. No feature of the Australian vegetation is more beautiful than the groves of these lovely palms.

Screw-pines (Pandanus) abound in this region and there are also a number of species of Cycads. Australia is especially rich in these ancient plants. The most widespread genus is Macrozamia, of which there are several species, the genus having representatives in all the states. The two other Australian genera, Cycas and

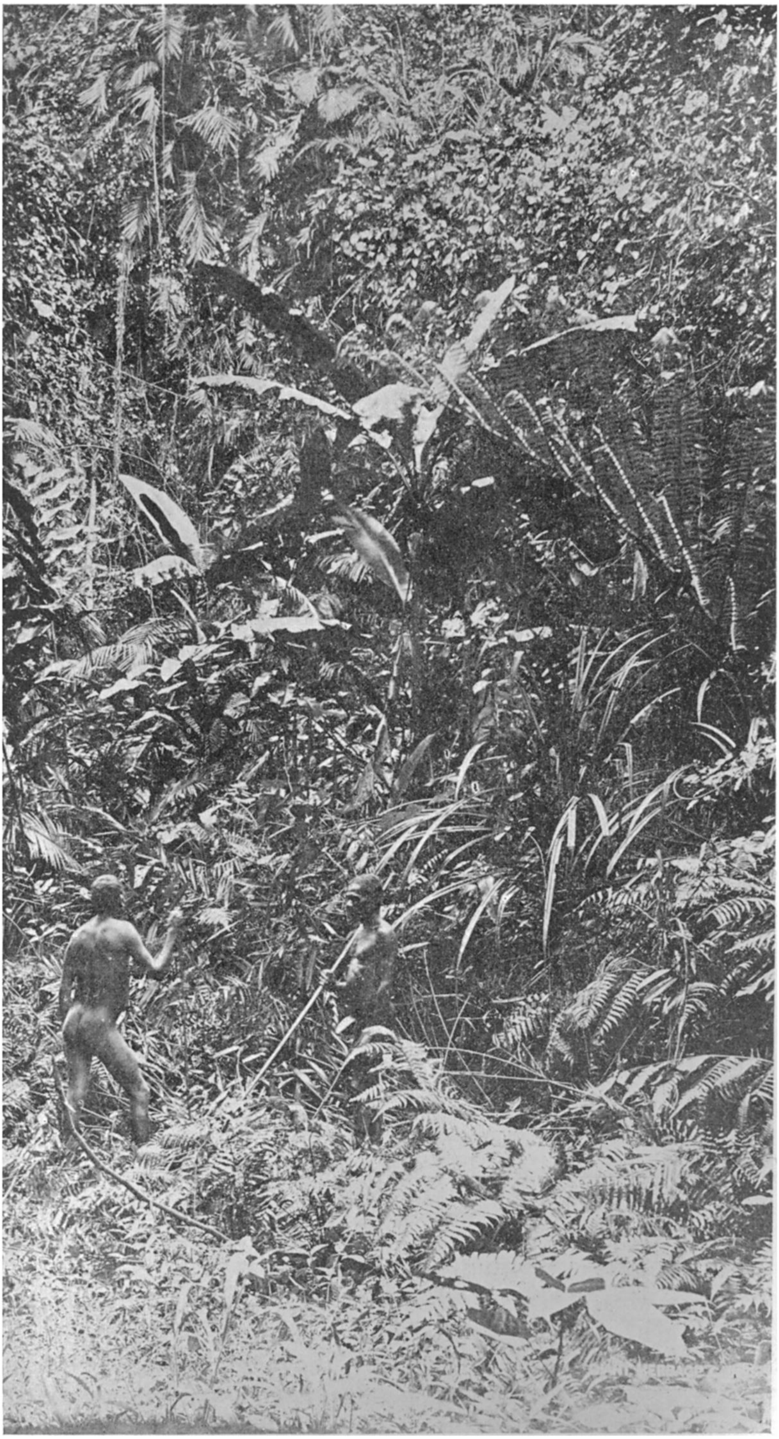

FIG. 1. TROPICAL RAIN-FOREST, NORTH QUEENSLAND

Bowenia, are confined to tropical Queensland. The latter genus, peculiar to Australia, differs much in appearance from any living Cycads, in its solitary bi-pinnate leaves, rather suggesting a bracken fern.

In the dryer parts of the Queensland coast the rain-forest is replaced by a more or less mixed forest, composed in part of Eucalyptus, and in part of tropical rain-forest types, like Ficus. A forest of this type may be seen occupying the sandy soil in the neighborhood of Cairns, the principal port of North Queensland.

A feature of the coast in this district is the mangrove formation along the shore and the banks of the streams flowing into the sea. Several genera are represented, the most important being the widespread Rhizophora and Avicennia.

Some interesting ferns were noted in this region, the most striking being a gigantic Angiopteris which was seen in several places in the vicinity of Babinda.

Immediately back of the coast the land rises rapidly to a plateau reaching an extreme elevation of about 4,000 feet, but averaging 2,000 to 3,000 feet over most of its extent.

This table-land has an ample rainfall, and on the better soils develops a fine forest which yields extremely valuable timber. Much of the timber has been destroyed, but there are still some remnants which are accessible, and these are really magnificent examples of tropical forest growth. This tropical rain-forest is known in Queensland by the very inappropriate name of "Scrub" and is confined to the rich basaltic and alluvial soils.

The trees of this forest are mainly of Malayan affinity, and are tall with lofty straight trunks yielding a large amount of fine timber. Some of them, especially the Kauri (*Agathis Palmerstoni*) and "Red Cedar" (*Cedrela toona*) reach a very large size. The latter was formerly abundant and sometimes attained a diameter of upwards of ten feet. It has been largely exterminated, but an occasional fine specimen may still be seen, and the same is true of the Kauri.

Belonging to the same family (Meliaceae) as the cedar are several species of Flindersia, which are locally known as "hickory," "maple," "beech," and other woods not in the least related to them. Other characteristic trees are Elaeocarpus, (Tiliaceae), *Aleurites Moluccana,* widespread throughout Polynesia; Sideroxylon (Sapotaceae), Eugenia (Myrtaceae) and others. The characteristic Australian family Proteaceae is represented in the rain-forest by several species of Grevillea, Stenocarpus, Macadamia and other genera. *Grevillea robusta* of southern Queensland is often grown in California as an ornamental tree.

This upland forest has much finer trees than the lowland forest

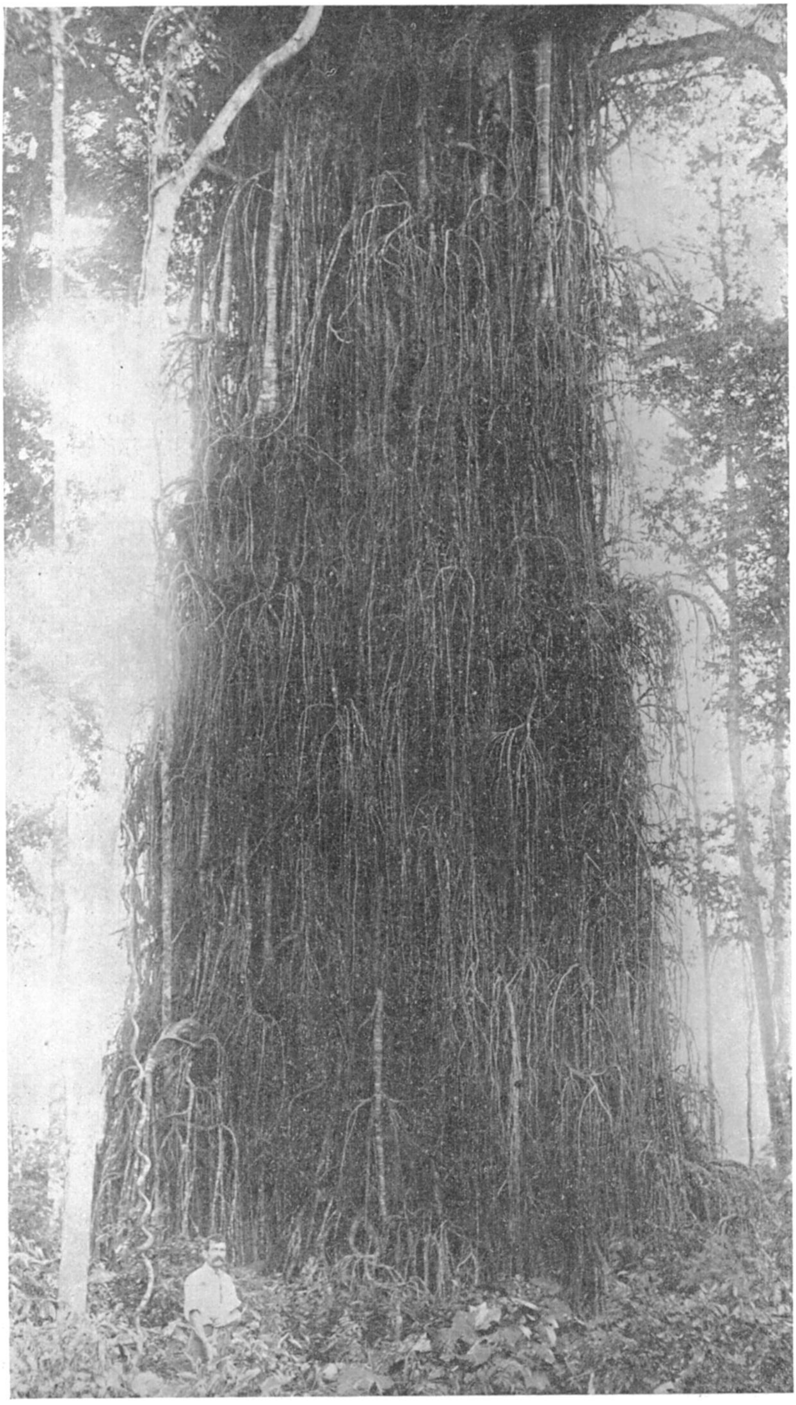

FIG. 2. TRUNK OF GIANT FIG, NEAR YUNGABURRA, NORTH QUEENSLAND

near the coast, but the palms and some other tropical types are almost entirely absent, and the development of the epiphytes and lianas is not so marked, although these are by no means absent. Many of the large trees, as is so common in rain-forests everywhere, show a conspicuous development of buttresses at the base of the trunk.

The giants of the forest are species of Ficus, the size of which is amazing. As in most tropical lands the genus is well represented in northern Australia, some species extending as far south as Sydney. Like so many other species of Ficus, these giant Queensland figs begin life as epiphytes, the descending roots finally coalescing more or less completely, and strangling the host tree. The descending roots are produced in great numbers and in one tree that was seen, the huge conical trunk formed by the united roots was said to measure 120 feet in circumference at the ground, and the enormous spreading crown was in proportion.

While the predominant forest on the plateau is "scrub," there are large areas occupied almost exclusively by open Eucalyptus forest. This Eucalyptus forest is the dominant type of vegetation over much of Australia, but in the region in question is restricted to areas of sandy soil. The line between the "scrub" and the Eucalyptus forest is often very sharply marked, and is probably determined by the difference in the soil.

In southern Queensland, in the neighborhood of Brisbane, the Eucalyptus forest predominates, though there are also areas occupied by "scrub," but many of the strictly tropical species of North Queensland are absent.

Probably the most striking tree of South Queensland is the "Bunya" (*Araucaria Bidwilli*) a coniferous tree confined to a relatively small area in this region. It reaches a large size, and is valuable for its timber. The big seeds were much prized as food by the aboriginals. This handsome tree is frequently cultivated in California, where it seems very much at home. A second species, *A. Cunninghamii,* is much more widely diffused, and was seen in extensive pure stands on some of the islands off the coast of Queensland.

An analysis of the constituents of the scrub vegetation of Queensland and New South Wales shows that it is largely made up of genera widespread through the Indo-Malayan region, or closely related to these, and may very properly be considered a part of the great Malayan flora. Such types as the figs, palms, screw-pines, Araceae, many epiphytic ferns and orchids are characteristic of the whole Indo-Malayan region; and as it is evident that northeast Australia was connected at no very distant period with the great island of New Guinea, it is pretty certain that this portion of the Australian flora is derived from the north.

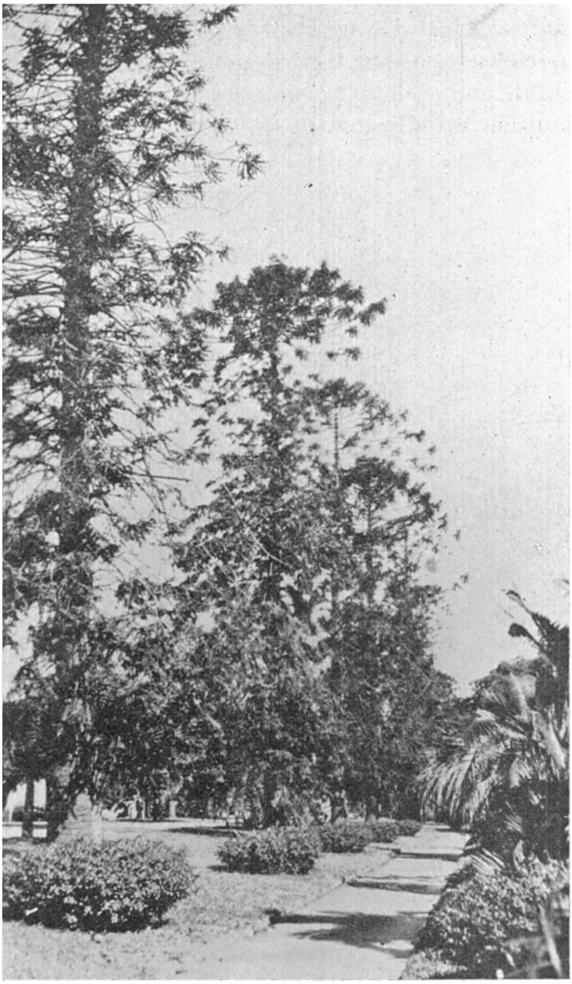

FIG. 3. BUNYA PINES (ARAUCARIA BIDWILLI), BOTANICAL GARDENS, BRISBANE

This Malayan flora is best developed in northeast Queensland, some of the forms like the pitcher plants (Nepenthes) and certain genera of palms (Borassus, Areca, Caryota, etc.) being confined to the York Peninsula, Australia's northernmost extension, which is separated from New Guinea by only about 100 miles of water.

Some of the Malayan types, like Cedrela and two or three palms, and a considerable number of others, extend southward to the borders of Victoria; but this vegetation is confined to regions of ample rainfall and rich soils, and the number of these Malayan types diminishes rapidly toward the south.

While the scrub vegetation is made up for the most part of the Malayan types there are a number of genera probably of Australian origin. Such are the fine trees Tristanea (allied to Eucalyptus) the silky oak (*Grevillea robusta*), Stenocarpus and Macadamia of the Proteaceae, a family which reaches its maximum development in Australia.

The luxuriant scrub-forest disappears as one proceeds inland, and with the diminishing precipitation is replaced by the open Eucalyptus forest. Still further inland in Queensland are extensive open grass lands or prairies which afford pasturage to great herds of cattle.[1]

To the south of Queensland is the state of New South Wales, the first colony to be established in Australia. The coastal region is a continuation of that of southern Queensland and has much the same vegetation as the latter, but the Malayan elements diminish toward the south, where there is an increasing proportion of true Australian types such as Eucalyptus and Acacia. The scrub, however, retains a decidedly tropical aspect, with tall palms and tree-ferns in abundance.

Much the greater part of the state, however, is far too dry for such forest growth, and is occupied by a very different type of vegetation. This is almost purely of Australian origin and is more or less decidedly xerophytic in character. The predominant trees are various species of Eucalyptus forming open forests with the sandy soil between occupied by a great variety of low shrubs, often with extremely showy flowers. Herbaceous plants are less conspicuous, although there are coarse grasses and a good many perennial plants growing from tubers, corms or bulbs. The Myrtaceae, so abundant in Australia, have numerous species of Leptospermum and Melaleuca; the Leguminosae include many species of Acacias, "Wattle" in the vernacular, and a bewildering array of showy Papilionaceae; several beautiful species of Boronia

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[1] Maiden, J. H.: "Australian Vegetation," p. 207. *Federal Handbook for Australia,* Melbourne, 1914.

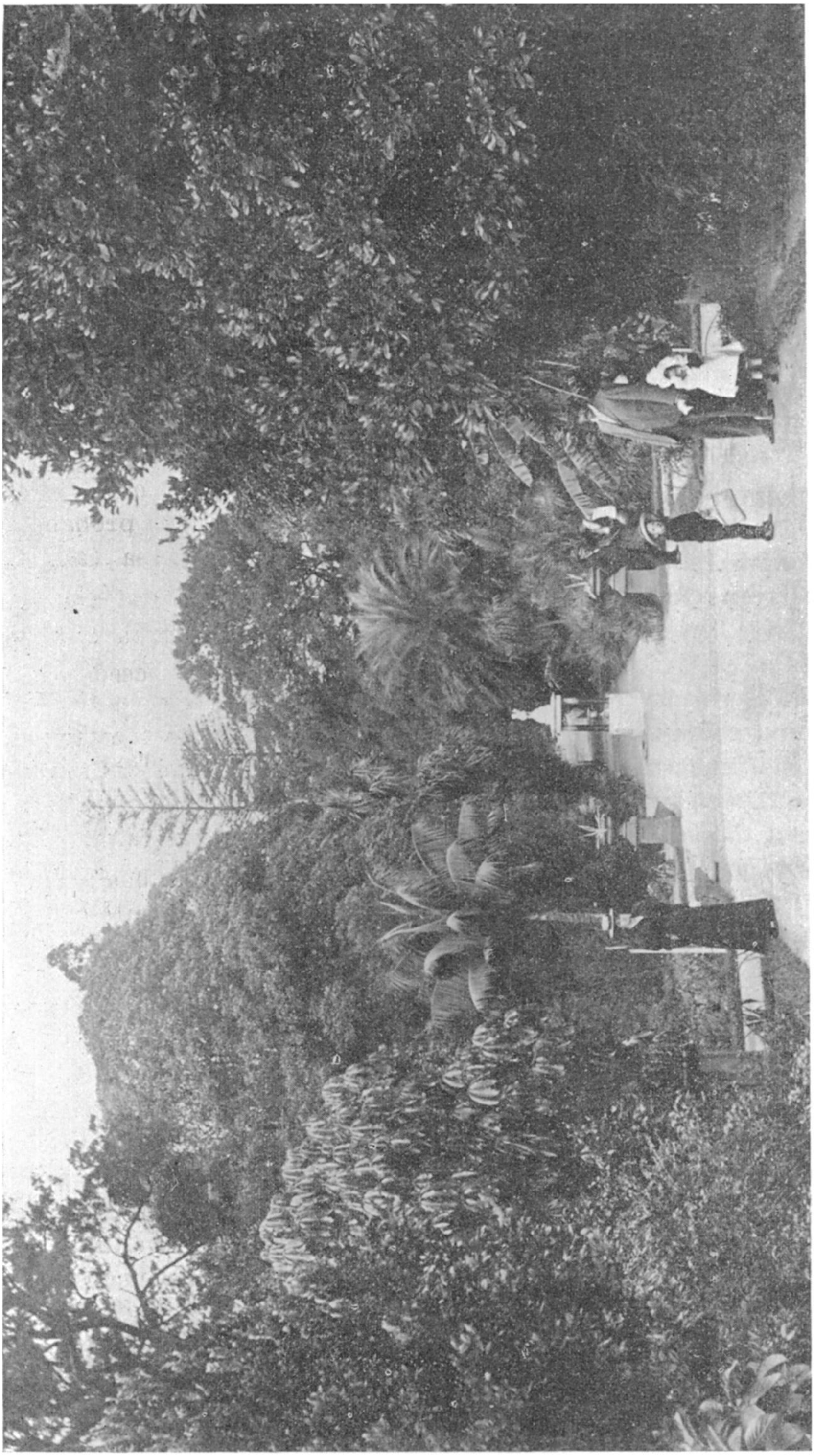


FIG. 4. BOTANICAL GARDENS, SYDNEY

and Eriostemon (Rutaceae) and many other striking and unfamiliar flowers abound. The Proteaceae, as everywhere in Australia, are much in evidence, the most abundant being species of Hakea, Banksia and Grevillea. To this family belongs one of the most gorgeous of Australian flowers, the ''Waratah,'' whose magnificent scarlet flowers are the pride of New South Wales. Another very striking plant peculiar to New South Wales may be mentioned—the giant torch lily (*Doryanthes excelsa*), bearing an enormous cluster of great scarlet lilies on a stout stalk ten or fifteen feet in height.

Victoria, the smallest state, occupies the southeast corner of Australia, and is about the size of Kansas. It is the best cultivated, and apparently the most prosperous state of the commonwealth. Much of the state has a climate adapted to the cultivation of most crops of the north temperate zone, and better suited to the North European settlers than the hotter parts of Australia. Its smaller size and more uniform rainfall result in a lesser variety of vegetation than in the larger states; but in the mountain districts of the east are found the tallest trees in Australia, close rivals of the California redwood. These forests of giant gums with their heavy undergrowth of tree-ferns and other luxuriant vegetation are among the finest in the world. Where the forest has been cleared, the land is some of the best in the commonwealth.

The distinctive Australian flora is seen at its best in West Australia. This immense state occupies the entire western third of the continent, and is almost completely separated from the eastern states by extensive deserts, and is itself very largely a region of extremely low rainfall. There is, however, a small region occupying the extreme southwest portion, which has a fairly heavy rainfall, and this district possesses a flora which for variety and beauty has scarcely a rival anywhere in the world.

Travelling overland from Victoria one traverses the rather uninteresting state of South Australia, and then proceeds by the recently completed line over the desert to West Australia.

This desert is not unlike certain parts of our own western arid regions, often suggesting parts of Nevada or Arizona. While extensive tracts show only sparse salt-bush (Atriplex, Kochia), much resembling the sage-brush deserts of Nevada or Utah, more often there is a fairly heavy growth of small trees, interspersed with low shrubs, and sometimes bunch grasses and a few flowering herbaceous plants.

The commonest trees are, as usual, species of Eucalyptus, but other abundant trees are species of Casuarina, whose thin leafless twigs simulate the needles of a pine. These curious trees, while not exclusively Australian, being also found in the Malayan region, reach their maximum development in Australia.

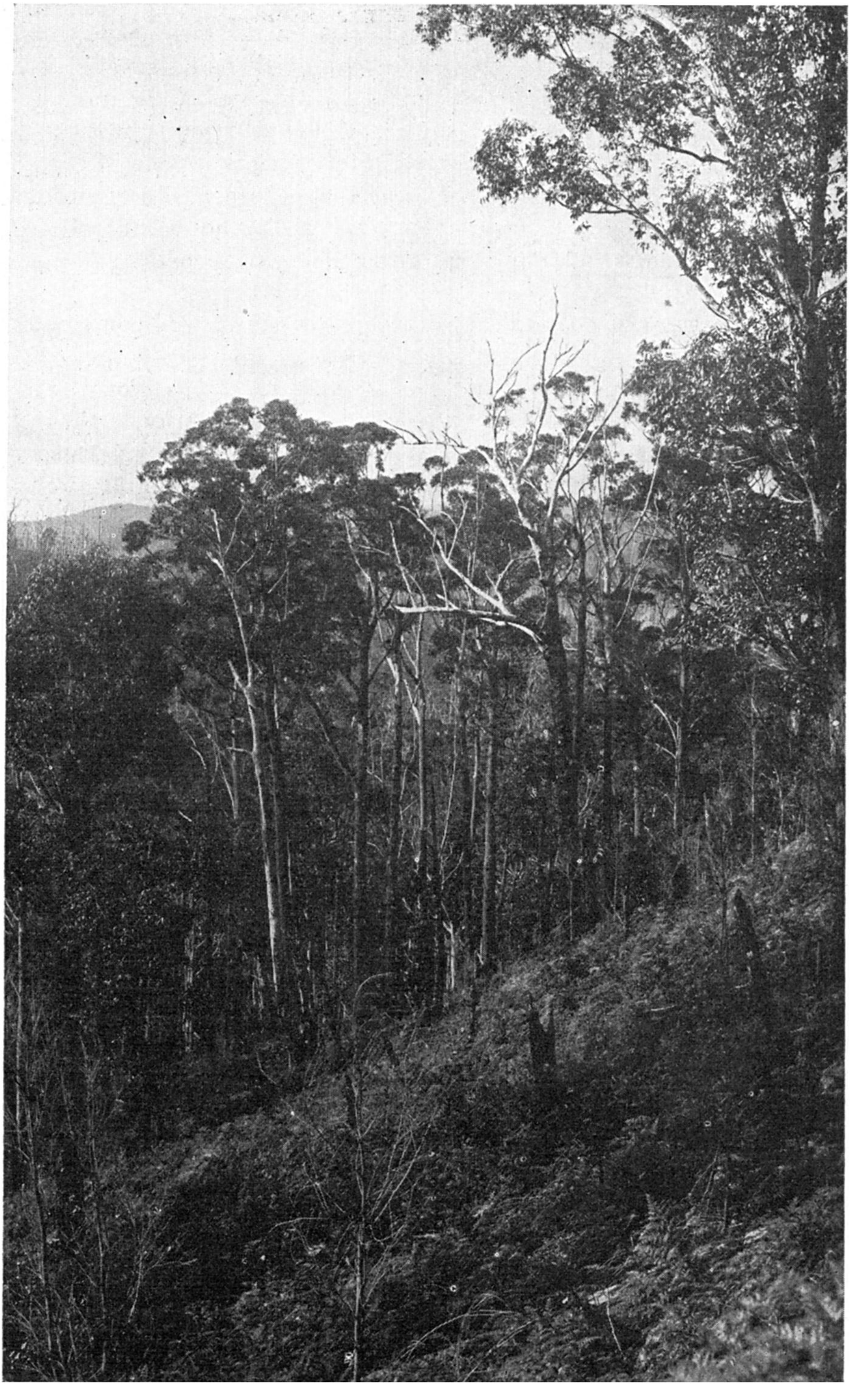


FIG. 5. GIANT GUM-FOREST, VICTORIA

The commonest shrubs are species of Acacia and dwarf Eucalyptus, the former at the time of my visit being covered with masses of golden bloom, which enlivened the prevailing dull gray green tints of the foliage. A species of sandal-wood grows in this region as well as a number of other interesting trees and shrubs.

Comparatively few showy flowers are seen, aside from the Acacias. Occasionally masses of pretty pink and white everlastings are encountered, and a gorgeous scarlet pea (*Clianthus Dampieri*).

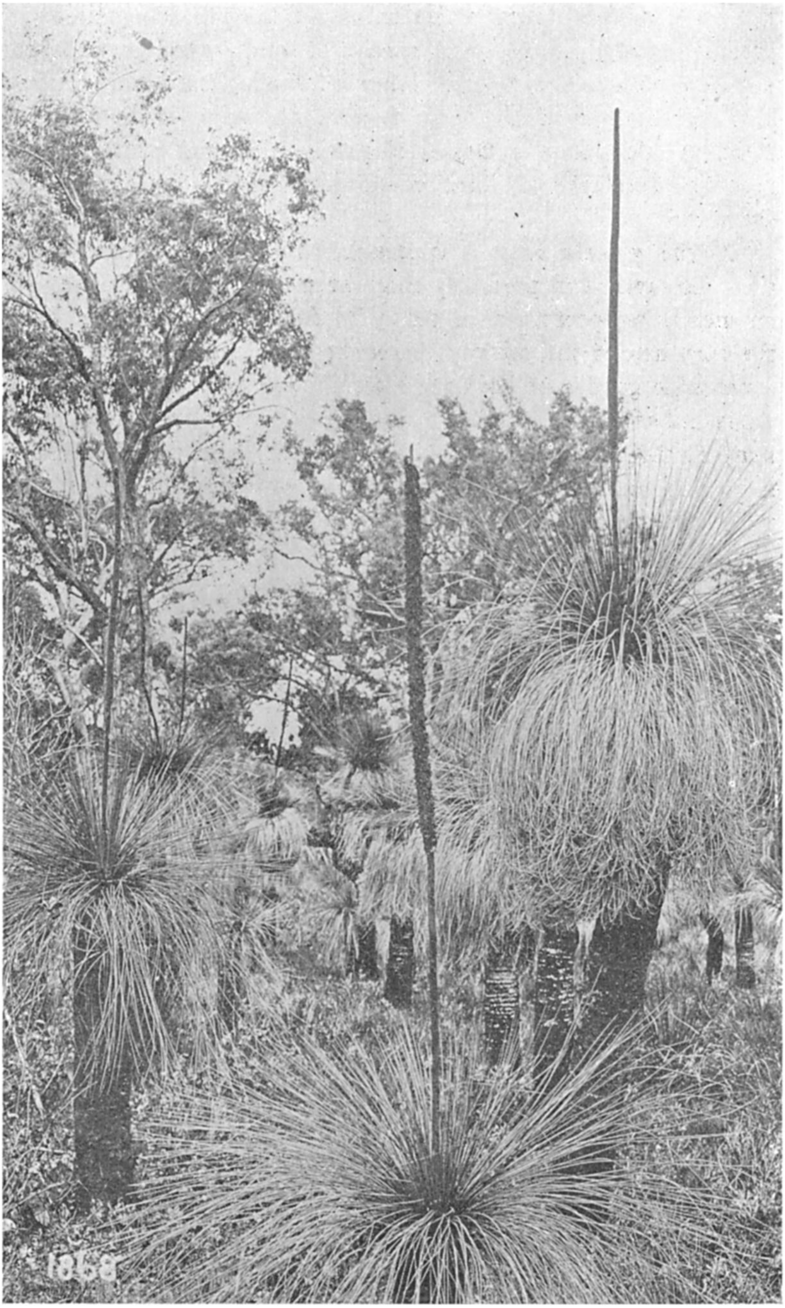
As the western coast is approached the country becomes somewhat less arid, and presently there appears along the railway line an increasing profusion of beautiful flowers, until before Perth, the terminus of the railway, is reached, the train travels through a veritable garden of brilliant bloom. The beauty and variety of this wonderful floral display must be seen to be appreciated. While some of the flowers, such as the great variety of pea-shaped blossoms, suggest familiar northern types, many are entirely strange with little suggestion of relationship with any northern genera.

Whole families, quite unknown to this northern botanist, are richly represented. Thus the Goodeniaceae, a characteristic Australian family, has a large number of extremely showy species of Goodenia (yellow), Dampiera and Leschenaultia (blue), one of the latter, *L. formosa,* of a wonderful blue that would put to shame an Alpine gentian.

Ground orchids are very abundant, some of them of great beauty. They belong largely to special Australasian genera, Caladenia, Diuris, Thelymitra and other quite unfamiliar ones. The little sundews of northern bogs are here represented by an extraordinary assemblage of species, some slender, half climbing plants four to five feet high with flowers the size of small roses. Pink Boronias and Tetratheca (Tremandraceae), yellow Hibberties (Dilleniaceae) are a few of the many beautiful novelties among the lower growing species; while Banksias, Hakeas and Grevilleas of the Proteaceae; Leptospermum, Callistemon, and Melaleuca of the Myrtaceae, are the predominant larger growths.

Of the Monocolyledons, aside from the orchids already referred to, and various grasses and sedges, there are a number of attractive species. The Iridaceae are represented by species of Patersonia with pretty blue or purple flowers. Of the lily-family are several species of Thysonotus, with delicate fringed petals, and Burchardia, whose umbels of pretty white blossoms suggest an Allium or the Californian Brodiæa.

Peculiar, if not beautiful, were the extraordinary grass-trees, or "black-boys," as they are commonly called in the West. The larger species develop a stout trunk and somewhat resemble an



Photograph furnished by Mr. C. E. Lane-Poole.

FIG. 6. GRASS-TREES (XANTHORRHŒA PREISSII), WEST AUSTRALIA

arborescent Yucca, but the leaves, which are very numerous, are slender and more or less drooping. The insignificant flowers are borne on a club-like spike, sometimes six or eight feet high. The plants are said to flower especially freely after a recent fire, and a grove of these strange plants with hundreds of these upright flower-spikes is one of the most striking botanical sights of Australia. A related genus, Kingia, is confined to western Australia.

Among the most extraordinary flowers of West Australia are the "Kangaroo Paws" (Anigozanthus). These flowers are of the most bizarre coloring—bright green and scarlet, yellow and black, red and yellow, or pure green. The genus is unknown outside West Australia. The only Gymnosperm noted was a Cycad, *Macrozamia Fraseri.* This is very common, and is regarded as a serious pest, as animals are often poisoned by eating the young foliage in time of drought. Throughout the less arid parts of West Australia, this wonderful floral display may be seen in the spring, August to November. It perhaps reaches its culmination in the Albany district on the south coast. Certainly the variety of flowers near Albany surpasses anything the writer has seen in any part of the world.

I was unable to visit the Island of Tasmania, which differs much in its topography and climate from the mainland of Australia, and is much more like New Zealand in these respects. It is very mountainous and in many parts, especially in the west, the rainfall is extremely heavy. This heavy precipitation and relatively low temperature resemble the climatic conditions in the south island of New Zealand, and there is a considerable degree of resemblance in the vegetation of the two regions.

In common with New Zealand there is an important element of the flora closely related to, or even identical with, South American species. Some of these "Fuegian" plants are found also in the parts of the adjacent state of Victoria and also as Alpines in the mountains further north.

The most striking of these are the evergreen beeches (*Nothofagus spp.*) which are a notable constituent of the flora of southern Chile and also of New Zealand. These are the sole representatives of the Cupuliferae (oaks, beeches, etc.) found in Australasia.

The visitor to Australia is immediately impressed by the predominance of the Eucalyptus forest, and indeed this is the commonest tree genus. While much of this open forest is extremely monotonous and unattractive, it must be remembered that among the more than two hundred species there are some of the stateliest and most beautiful trees known anywhere. The great Karri forests of West Australia and the giant gum forests of Victoria, as well as some of the Eucalypts from the rich mountain forests of New South Wales and Queensland, are some of the most magnificent the writer has ever seen.

In the spring, when the new foliage is developing, many species show beautiful golden and ruddy tints in the young leaves that are in strong contrast with the gray-green of the adult foliage of most species. In the arid regions of the interior there are dwarf species shrubs of moderate size remarkably resistant to drought.

The flowers of some species of Eucalyptus are very beautiful and produced in great profusion. As in so many Myrtaceae the numerous stamens form the showy part of the flower and are pure white, pink or scarlet in color. The splendid *E. ficifolia* with brilliant scarlet stamens is a favorite ornamental tree in parts of California.

The Myrtaceae, aside from Eucalyptus, are very largely developed in Australia, being second in number of species in the Australian flora,[2] more than eight hundred having been described. Allied to Eucalyptus are Tristanea, Angophora and Syncarpia, all fine trees of large size.

In the moister and warmer areas of the coast are members of the widespread genera Myrtus, Eugenia and Barringtonia, the latter entirely tropical in its habitat, a very beautiful tree with large glossy leaves and big white flowers. The genus is common throughout the Malayan region and the southern islands of Polynesia.

More characteristically Australian and represented by many species are the genera Leptospermum and Melaleuca, very widely distributed and often forming extensive thickets. Some of the Melaleucas are small trees; the Leptospermums are as a rule shrubs of medium size. The flowers are usually white and produced in great profusion, so that some species are very attractive when in flower and prized as garden ornaments. Other characteristic Myrtaceae are the showy red "bottle-brushes"—species of Callistemon and the pretty fringed flowers of the West Australian Verticordias.

First in number of species in the Australian flora is the great family of Leguminosae, with over one thousand species. Acacia leads with upwards of four hundred, ranging from tiny shrubs a few inches in height to large trees. The Acacias are popularly known as "wattle," and in the spring the profusion of golden bloom of many species makes them very conspicuous. Some of these Australian wattles are common in cultivation and often called "Mimosa." The majority of the Australian Acacias are of the "phyllodineous" type, *i. e.*, the feathery leaf-lamina is suppressed and the flattened leaf-stalk, or "phyllode," looks like a simple lanceolate leaf.

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[2] Maiden, *loc. cit.*, p. 166.

The section Papilionaceae, or Pea family, contributes a host of showy flowers to the floral show. Nearly all of these exhibit very brilliant colors, pink, crimson, scarlet, orange, yellow, blue and purple, and the flowers are borne in profusion. Many belong to strictly Australian genera—*e. g.*, Chorizema, Gastrolobium, Jacksonia, etc., and comparatively few are in cultivation.

The third family, in point of numbers, the Proteaceae, has not a single representative in the United States, and is almost entirely absent from the northern hemisphere. About two thirds of the species belong in Australia, and South Africa is next in number of species. The Proteaceae are mostly shrubs of moderate size, but a considerable number are arborescent, becoming forest trees. Of these trees, the most important are the species of Grevillea Banksia, Stenocarpus, Macadamia and several others peculiar to the rain-forests of Queensland. The handsome *Grevillea robusta* is a fine tree frequently seen in California, and a few other species of Grevillea and Hakea are less commonly seen in gardens; but many fine species, well worth cultivation, are still to be seen only in the wild. Grevillea is the largest genus and is widespread in Australia. The flowers are often very showy, pink, scarlet or yellow. Hakea, next in number of species, has as a rule rather inconspicuous flowers.

Few Australian trees are more peculiar in habit than some of the Banksias, whose stiff serrate leaves and huge oblong heads of yellow flowers are most peculiar and striking. The great majority of the Proteaceae are xerophytic, but a few inhabit the scrubs of New South Wales and Queensland. Perhaps the finest flowers among the Proteaceae belong to the "Waratah" of New South Wales, previously referred to. Other important families, nearly or quite confined to Australia, are the Tremandraceae, Goodeniaceae, Candolleaceae and Casuarinaceae.

Reference has already been made to some of the Australian Gymnosperms, which are extremely interesting. The Cycads have already been mentioned, as well as the Araucarias and Kauri of Queensland. The coniferous types of the northern hemisphere are absent, the nearest relation being the genus Catlitris, which is related to the cypresses.

The Yew family or Taxaceae, however, is remarkably developed in the southern hemisphere and has a number of extremely interesting forms in Australia and especially Tasmania. Podocarpus, of which a small number of species occur in the warmer parts of the northern hemisphere, is the most important Australasian genus, and comprises a number of large and valuable trees, as well as some smaller ones. Species occur in all the states.

Certain genera, absent from the mainland, are found in Tasmania and New Zealand. Such genera are Phyllocladus and Dacrydium, as well as several others.

Ferns and their relatives are scarce or entirely wanting in a very large part of Australia, owing to the prevalence of arid and semi-arid conditions unsuited to these moisture-loving plants. There are, however, regions where they abound and are an important feature of the vegetation. The ubiquitous bracken-fern (*Pteridium aquilinum*) often covers large tracts of open land, as in northern regions; and in the moist gullies of the Blue Mountains of New South Wales and the forests of Victoria or in the rain-forests of the north there is a rich assortment of Pteridophytes, including some very fine treeferns, interesting Lycopods and the curious Psilotum and Tmesipteris, whose life-histories, which long baffled the botanist, have at last been revealed through the labors of Lawson and Holloway.

In the rain-forests are many epiphytic species, of which the extraordinary stag-horn ferns (Platycerium) are the most conspicuous; but there are also a good many of the beautiful and delicate filmy ferns (Hymenophyllaceae).

NEW ZEALAND

New Zealand comprises two large islands of about equal size and several adjacent ones of very much smaller dimensions. The northernmost point of the North Island is about 34° south latitude, and the South Island extends to south latitude 47°. The total area of the islands is about 100,000 square miles.

New Zealand presents a marked contrast to Australia, both in its topography and climate. Its relatively small area results in a climate of distinctly insular character, with very much less range of temperature and precipitation than is the case in continental Australia. Owing to its higher latitude, the climate as a whole is rather cool, but severe cold is rare in the lowlands. It is comparable with the climate of Britain, but especially in the North Island is considerably warmer. Owing to the proximity of the sea, there is less difference between North and South than might be expected. Thus between Auckland in the North Island and Invercargill, about ten degrees further south, there is less than ten degrees difference in the average temperature.

For the most part rain is abundant and well distributed, and much of the country shows a luxuriant growth of forest. There are certain regions, however, notably the Canterbury Plain of the South Island, which have a relatively scanty rainfall and are mostly destitute of trees. These grass-covered plains may be compared to the prairies of the mid-west of the United States.

The topography of New Zealand is for the most part exceedingly rugged, with much higher mountains than those of Australia. In the North Island are extensive volcanic formations, some of which are still active. In the Rotorua district, familiar to tourists, are numerous hot springs and geysers much like those of the Yellowstone and in addition there are active volcanic craters.

In the neighborhood of Auckland are a number of very perfect extinct cones, and on the west coast is Mt. Egmont, over eight thousand feet high. To the south lies the Wellington district, extremely rugged in character. The harbor of Wellington, surrounded by steep mountains, opens into Cook's Strait, separating the North and South Islands.

The South Island shows less extensive evidences of volcanic activity than the North Island. It is distinguished by the lofty snow-clad range of the Southern Alps near the west coast, culminating in the majestic Mount Cook, over twelve thousand feet high, snow covered for most of its height and with extensive glaciers reaching nearly to its base. The southwest coast is indented by numerous fiords, which are said to present a magnificent spectacle.

The Southern Alps exercise a great influence on the climate of the South Island, intercepting a very large part of the moisture from the seaward side. Between the mountains and the coast there are stations with as much as two hundred inches of rain annually, while Christchurch on the east coast has only about twenty-five inches, and there are a few stations with even a lighter precipitation. This dry region is mostly destitute of trees, the ground being covered with coarse tussock-grasses. The contrast between these dry grasslands and the densely forested regions of rainy Westland is most striking.

To the south of the great mountain range the conditions are more uniform, and the whole southern end of the South Island is covered with forest.

The North Island originally was almost completely covered with heavy forest, in which the most important tree was the Kauri pine (*Agathis australis*). Very little of this splendid forest remains, and the Kauri is almost extinct. A few small tracts have recently been reserved, and I had an opportunity of visiting one of these in the extreme northern part of the island. This new park is of limited extent, but is a typical example of the magnificent Kauri forest which once covered the desolated regions now occupying most of the surrounding country.

The Kauri is entirely different in appearance from any conif-

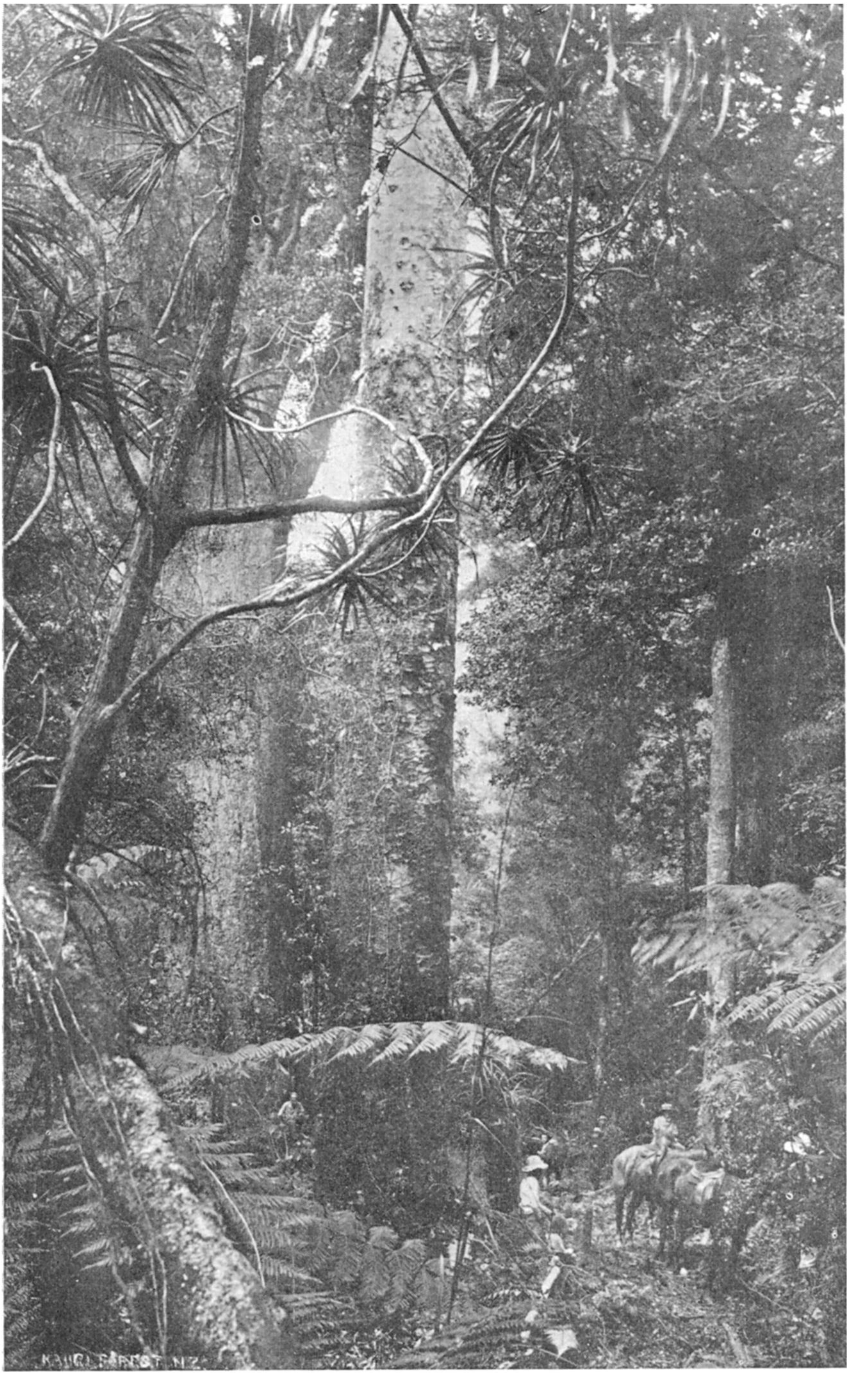


FIG. 7. KAURI FOREST, NORTH ISLAND, NEW ZEALAND

erous tree with which the American botanist is familiar. In its younger stages it shows the symmetrical pyramidal habit of most conifers, but the early branches finally fall off, leaving a perfectly smooth cylindrical bole with very little taper. This columnar trunk may reach a height of sixty to eighty feet, or even more, with a diameter of eight to ten feet, or it is said of twice this size. At the top there are several enormous diverging branches forming an immense spreading crown which overtops the other trees of the forest and gives the tree a most characteristic appearance.

The interior of the Kauri forest, with the huge smooth gray columnar trunks, is most impressive, and only rivalled by the great coniferous forests of the Pacific Coast, or the Cyptomerias of Japan. The New Zealand Kauri must rank as one of the giants of the vegetable kingdom.

Associated with the Kauri are a number of other trees, including several other Conifers or rather Taxads, as these belong to the Yew family. Of the latter the most important are the "Totara" (*Podocarpus Totara*) and "Rimu" (*Dacrydium cupressinum*), both valuable timber trees. The curious *Phyllocladus trichomi-noides* with flattened twigs (cladodes) looking like small fern-leaves, is not uncommon in this region. Some other characteristic trees are *Weinmannia sylvicola* (Saxifragaceae), said to be the commonest tree in New Zealand, and *Beilschmiedia taraire,* belonging to the Lauraceae.

A number of fine shrubs, *e. g.,* Coprosma, Pittosporum, Nothopanax and others are common, and as in all New Zealand forests ferns are much in evidence. The abundant and beautiful tree-ferns lend a special charm to the New Zealand forest. The finest of these is *Cyathea medullaris,* which may reach a height of upwards of fifty feet and is the finest tree-fern with which I am acquainted.

Other interesting ferns are several species of Gleichenia, and the climbing fern, *Lygodium articulatum,* which is said to climb to the top of lofty trees. Filmy ferns (Hymenophyllaceae) are common in the damp shady woods, but are hardly as abundant or luxuriant as in the rain-forests of the South Island.

Epiphytes abound in the rain-forests and include many conspicuous mosses and liverworts as well as ferns and various flowering plants. Among the latter are a number of orchids, but these are mostly inconspicuous species, far inferior in beauty to some of the fine Australian epiphytic orchids. Perhaps the most conspicuous epiphyte is a very common liliaceous plant, *Astelia solanderi,* forming great tufts of stiff sword-shaped leaves on the trunk or branches of many trees. It very often is seen on the slender stem of the Nikau palm, forming great bunches completely surround-

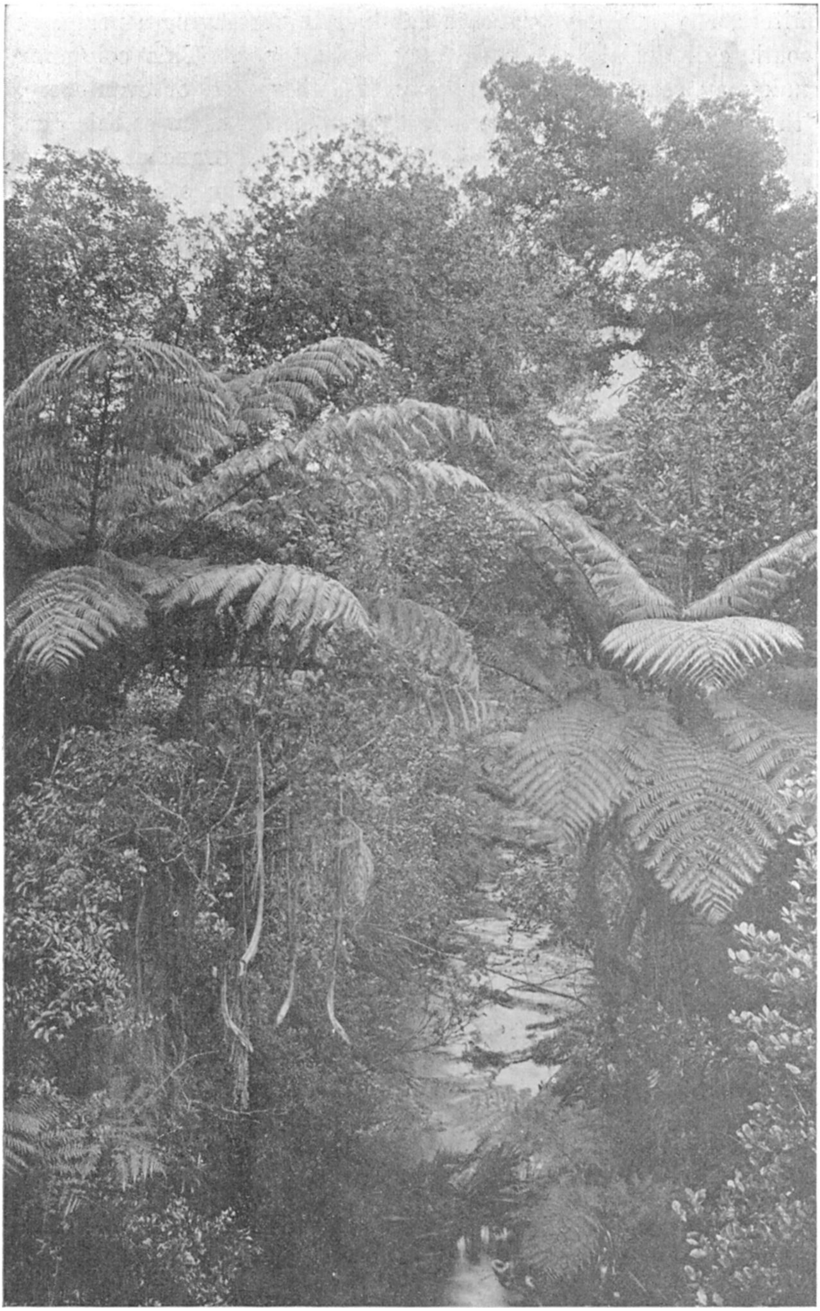


FIG. 8. TREEFERNS, NEW ZEALAND

ing the trunk. This palm (*Rhopalostylis sapida*), is the only palm native to New Zealand.

Where the land has been cleared it is often invaded by the ubiquitous bracken (*Pteridium aquilinum*), and another plant which quickly takes possession is the ''Manuka'' (*Leptospermum scoparium*), closely resembling some of the Australian species. When in bloom the shrub is decidedly ornamental, with myriads of pretty white flowers.

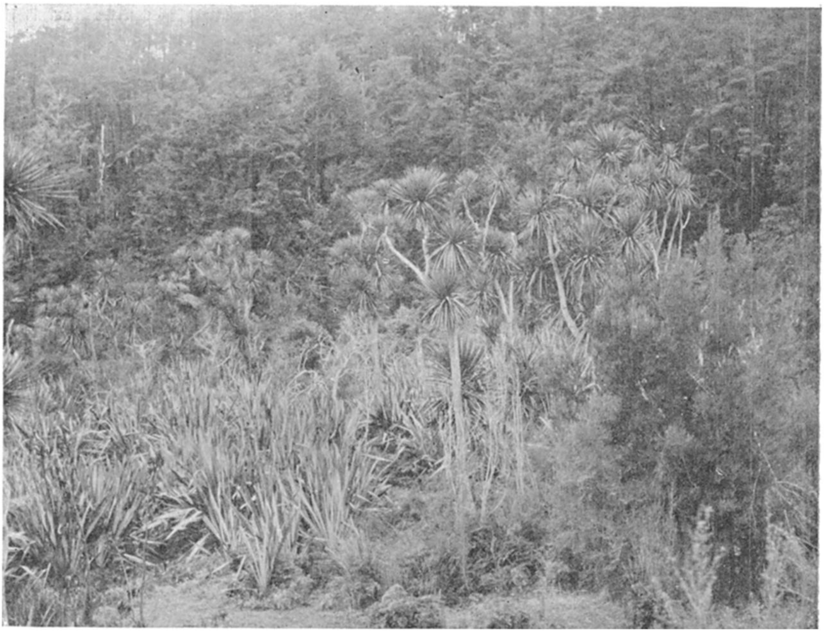
In open, more or less swampy districts, all over New Zealand, two extremely characteristic plants can hardly fail to attract attention. These are the native ''flax'' (*Phormium tenax*) and the ''cabbage-tree'' (*Cordyline australis*), often grown in California under the name Yucca-palm. The flax yields an abundant and valuable fibre, which is manufactured on an extensive scale and is one of the most important products of the country. At the time of my visit both of these striking plants were in flower. The flax sends up from its tuft of broad leaves, five or six feet high, scapes about twice as tall, bearing racemes of tubular red flowers which are much frequented by honey-sucking birds. The stately Yucca-like Cordylines bear immense panicles of small white fragrant flowers.

Among the most widespread trees of New Zealand are several species of Metrosideros, a genus occurring throughout Polynesia and Australasia. *M. robusta*, the ''Rata,'' is a very beautiful tree with glossy green leaves and bright red flowers. Like Eucalyptus, to which it is not very distantly related, the bright-colored stamens are the showy part of the flower. Another species, *M. tomentosa*, also with showy flowers, is abundant about Auckland, and several other species, some of them climbers, occur in various parts of New Zealand. *M. robusta* begins life as an epiphyte, the trunk of the older tree being made up of the united descending roots, as is so often the case in many species of Ficus.

The southern portion of the North Island has a somewhat different vegetation from that of the Auckland district. The Kauri is quite absent from this region, and in some districts there are forests of evergreen beeches much like those of the South Island.

In the immediate vicinity of Wellington the forest shows many of the same trees as that further north, *e. g.*, Podocarpus, Dacrydium, Metrosideros, Weinmannia, Beilschmiedia and others. Among these is one of the two species of Proteaceae found in New Zealand. This is a handsome tree, *Knightia excelsa*, somewhat resembling the Australian Banksias.

One of the most interesting small trees is a Fuchsia, *F. excorticata*, New Zealand having three species of this otherwise exclusively South American and Mexican genus.



Photograph by Dr. L. Cockayne.

FIG. 9. CABBAGE-TREES (CORDYLINE AUSTRALIS) AND NEW ZEALAND FLAX (PHORMIUM TENAX)

Shrubby Compositae are common in New Zealand. The genus Olearia, much like Aster, is well represented, some species having fine flowers, others like *O. ilicifolia* with handsome evergreen foliage. Another peculiar genus is *Raoulia,* which includes the "vegetable sheep," *R. eximia.* Some other characteristic shrubs noted near Wellington are species of Melicytus, Elaeocarpus, Myrsine and Sophora. *S. tetraptera,* with brilliant yellow, very conspicuous flowers, is one of the few really showy New Zealand shrubs.

Wellington has an attractive if not large botanical garden of which the most interesting feature is a small ravine in which are growing many of the native trees and shrubs as well as some fine ferns and liverworts. Some of the treeferns are very tall and make a fine show. Of the liverworts the most notable is the remarkable *Monoclea Forsteri,* a giant among liverworts. This species is abundant about Wellington and also in various part of the South Island. The only other species known occurs in tropical America.

In the botanical gardens in Wellington are some fine exotic conifers, including a number of Californian species. One of these, the Monterey pine (*P. radiata*) is extensively planted in New Zealand, where it grows with extraordinary rapidity and furnishes a large amount of timber.

Across the harbor from Wellington at Day's Bay is a considerable extent of forest made up almost exclusively of two species of evergreen beeches (*Nothofagus fusca* and *N. Menziesii*). This forest is much more open than the mixed forest which prevails over most of the country near Wellington. These beeches, except for their much smaller leaves, are not unlike the true beeches of northern forests. They also remind one, in general habit, of the tree alders of the Pacific Coast.

Cook's Strait, separating the North and South Islands, does not seem to form an appreciable barrier to the migration of plants between the islands, there being little difference in the vegetation on the two sides of the Strait. Probably the separation of the two islands took place at a comparatively recent date, so that there has not been time for any marked change in the vegetation.

The important city of Christchurch is surrounded by the famous Canterbury Plain, an open grassland which like our western prairies is admirably adapted to agriculture.

The trip across the South Island from Christchurch to the west coast is full of interest to the botanist and includes some magnificent scenery. I had the good fortune to be accompanied by Dr. L. Cockayne, the well-known botanist, whose knowledge of the native flora is both extensive and accurate.[3]

The Canterbury Plain, where it has not been cultivated, is covered with tussocks of coarse grass, and this is true also of the lower slopes of the mountains on the eastern side. The most abundant species is *Festuca Novae Zealandeae,* but *Poa caespitosa* was another common and conspicuous species.

The change from this open grassland to the first beech forest is very abrupt, and marks the beginning of the western rainy district. The beech forest is very dense, and composed exclusively of the mountain beech (*Nothofagus Cliffortiana*).

At the summit of Arthur's Pass, about 3,000 feet elevation, the increasing moisture becomes more evident. The open stony ground supports a heavy growth of herbaceous plants and low shrubs. In this formation is found perhaps the most beautiful of all new Zealand flowers, *Ranunculus Lyallii.* This fine plant has very large undivided peltate leaves, and clusters of pure white flowers two inches or more in diameter, borne on stout stalks a foot or more in height. Another charming flower is *Ourisia macrocarpa,* with large flowers something like Mimulus.

[3] Dr. Cockayne's book, "New Zealand Plants and Their Story," Wellington, 1919, is an admirable account of New Zealand vegetation.

The sub-alpine scrub of this region is composed of a number of very characteristic species. The most casual observer cannot fail to note the Dracæna-like *Dracophyllum Traversii,* a small tree with clusters of reddish leaves at the tips of the straggling branches. In spite of its Yucca-like habit, this is a heath of the family Epacridaceae. Various shrubby Veronicas, a genus developed to a remarkable degree in New Zealand, are abundant and several shrubby Compositae (Olearia, Celmisia, Senecio) abound. A curious leafless leguminous shrub, *Carmichœlia sp.,* is noted and a species of Gaultheria, and an Araliad (*Pseudopanax lineare*) are not uncommon. Along the roadside the mountain flax (*Phormium Colensoi*) is frequent. The descent on the west side, through the magnificent Otira Gorge, is one of the finest pieces of scenery in New Zealand. The very steep walls of the gorge are densely covered with luxuriant forest from crest to base.

The very heavy rainfall of this district is attested by the luxuriant rain-forest which reaches its maximum development on the west side of the range. At first there is some admixture of beech, but this finally disappears and in the typical Westland rain-forest is quite absent.

The banks along the roadside show a constantly increasing profusion of ferns, liverworts, and moisture-loving herbs, like violets, Hydrocotyle and the interesting Gunnera, a genus particularly developed in New Zealand.

Tree-ferns, which had not been seen at the higher elevations, increase in size and numbers as the lowlands are approached and in the lowland forest form a conspicuous and beautiful feature.

The Westland rain-forest is one of extraordinary luxuriance. The extremely heavy precipitation and mild temperature result in a rich profusion of vegetation that has all the aspects of a genuine Malayan rain-forest. Composed of exclusively evergreen trees and shrubs, draped with lianas and epiphytes and interspersed with thousands of noble tree-ferns, it was hard to believe that this forest was in latitude 43°, corresponding in the United States to the latitude of Buffalo.

This forest is of the type called "Taxad" by Cockayne, the most important trees belonging to the taxaceous genera Podocarpus and Dacrydium. In the swampy areas the "white-pine" *P. dacrydioides* predominates, a very tall tree with fine straight trunk yielding valuable timber. Of the angiospermous trees the most abundant is *Weinmannia sylvicola,* a tree of Malayan affinity, and its relative, *Quintinia acutifolia,* both belonging to the Saxifrage family. A very common large shrub is *Aristotelia racemosa,* with rather attractive pinkish flowers, and other common shrubs are species of Coprosma, *Metrosideras lucida,* and *Pseudopanax crassifolia.*

Ferns and other Pteridophytes abound in these wet forests. Various species of Lycopodium are abundant, and also the curious Tmesipteris. Of the tree-ferns, the commonest is *Dicksonia squarrosa,* sometimes twenty to thirty feet high. Less abundant is *Hemitelia Smithii.* Of the abundant epiphytic growths the most beautiful are the filmy ferns (Hymenophyllaceae) which in these Westland forests attain their finest development. Another extremely beautiful fern is *Todea* (*Leptopteris*) *superba.*

As might be expected, these supersaturated forests are a veritable garden of mosses and liverworts which drape the trees and form a thick carpet on the ground and big cushions over every prostrate log and stump. Great tussocks of Sphagnum are common about the pools, and now and then one encounters colonies of the giant *Dawsonia superba,* the last word in moss development.

The abundance and luxuriance of the liverworts is astounding; indeed, it is doubtful if anywhere else in the world is a richer growth of these interesting plants to be found.

Of the lianas the most interesting is *Freycinetia Banksii,* a distinctly tropical genus belonging to the screw-pine family, abundant throughout Polynesia and the Malayan region.

Everywhere in the New Zealand rain-forests there is a rich development of epiphytes and climbing plants. Of the epiphytes there are two categories, those that begin life as epiphytes, but later become rooted in the ground, and those which retain permanently the epiphytic habit. Among the latter are many ferns, Lycopods, Mosses and liverworts, as well as a good many flowering plants like Peperomia, various orchids, Astelia, etc. Of the ferns the filmy ferns or Hymenophyllaceae are especially numerous and beautiful.

Several species of New Zealand trees begin life as epiphytes. The seeds germinate in the branches of some tree and presently the young plant sends out roots which descend the trunk of the host-tree until they reach the earth. In course of time these descending roots coalesce in a more or less solid trunk and the host-tree may be completely strangled in the process. The "rata" (*Metrosideros robusta*) is the best known of these temporary epiphytes. Others are *Dracophyllum arboreum* and *Griselinea littoralis.*

Some of the climbing plants are great woody lianas, whose stout cables are thrown from tree to tree. One of the biggest of these is a huge bramble, *Rubus australis,* whose stems, sometimes six inches in diameter at the base, reach the tops of the tallest trees. Freycinitia climbs by means of roots, clinging to the trunks of trees, and some species of Metrosideros have a similar habit. Other common climbing plants are species of Clematis, Parsonsia and Mühlenbeckia and the climbing fern *Lygodium articulatum*.

Compared with Australia there is a remarkable scarcity of brilliantly colored flowers, a large proportion of the plants having white or greenish flowers. The bright red flowers of some species of Metrosideros, *Clianthus puniceus* and the native flax, bright yellow of *Sophora tetraptera,* the blue of many Veronicas and the blue or purple of some of the Compositae are the most marked exceptions to the rule.

WEEDS

As in all countries where the white man has settled there have come with him many plant immigrants, some of which are not entirely welcome. These weeds hail from many lands. In the hotter and dryer parts of Australia they may come from such tropical countries as India, Brazil or Africa, while in the more temperate regions of southern Australia and New Zealand they are largely from northern Europe and America, *e. g.,* thistles, sorrel, dock, plantain and other familiar weeds.

Parts of Australia have been invaded by species of prickly pear (Opuntia) from America, which are a very serious pest. It has been said that in Queensland 30,000,000 acres of land have been invaded by one species which has caused immense damage.

From America have also come species of cockle-bur (Xanthium) and Stramonium, as well as several other pestilent weeds. In the moister cooler regions of Australia and New Zealand, the common European blackberry, sweet brier and gorse have escaped from cultivation and become very persistent and troublesome weeds.

A number of plants from the Cape, whose climate is very similar to that of Australia, have become completely naturalized. It is not uncommon to see the familiar calla growing in ditches and low ground, and several of the beautiful Iridaceae from South Africa—Ixia, Sparaxis, Watsonia and Homeria—very often are seen growing along the railway embankments. The latter is said to be poisonous and may perhaps be called a weed. This name may also be given to the "Cape-weed" (*Cryptostemma calendulacea*), a daisy-like Composite which is extremely abundant.

CONCLUSION

Attention has already been called to the evident close relationships existing between the Australian "scrub" floras and those of the Indo-Malayan regions. The rain-forests of Queensland and New South Wales may be looked upon, with little question, as the remnants of a much more extensive flora which occupied these regions when they were united with New Guinea and separated from the ancient Western Australian continent. It is generally believed that in the latter, which was probably much larger than at present, the ancestors of the characteristic types which now dominate the flora of the greater part of modern Australia had their origin.

In the old Western continent, completely isolated from other lands, there was an extraordinary development of a comparatively small number of families. The most conspicuous examples of this are the Myrtaceae, with over 200 species in Eucalyptus alone; Leguminosae, especially Acacia with over 400 species, and many peculiar Papilionaceae; Proteaceae with over 600 species (Grevillea, Hakea, Banksia, etc.). A few families, *e. g.,* Candolleaceae, Goodeniaceae, are almost exclusively Australian and especially abundant in Western Australia.

These peculiar Australian plants are largely xerophytic, and after the union of Eastern and Western Australia it may be assumed that the extreme aridity and poor soils of much of the central part of the continent would be much more favorable to these Western xerophytes than to the Malayan types of the East which have evidently been largely evicted by the drought-resistant West Australian immigrants, and are now restricted to comparatively limited areas where there is good soil and abundant moisture.

The autochthonous types have for the most part remained in Australia. Eucalyptus, Acacia, a few Proteaceae and some others are represented in the savannahs of Southern New Guinea and the dryer portions of the Malay Archipelago; and a few genera range through Polynesia; but the great majority of the true Australian species are unknown outside the Australian continent.

In the southeast, and especially in Tasmania, there is a marked infusion of plants whose relationships are with the Andean and Fuegian vegetation of South America. Most of these occur also in New Zealand.

Comparing New Zealand with Australia, there is found a good deal in common in the floras of the northern districts, *i. e.,* the Malayan rain-forest vegetation. This type is, however, of very much greater importance in New Zealand, where in spite of a much cooler climate, a large proportion of the trees and shrubs are more or less closely related to Malayan ones.

There is strong evidence of former connections with the tropical regions to the North, and it is quite as likely that the Malayan genera which New Zealand shares with Australia have been derived from the North and not directly from Australia.

The distinctively Australian genera are relatively few in New Zealand, and a striking feature of the flora is the absence of such predominant Australian genera as Eucalyptus and Acacia. The family Myrtaceae, with over 800 species in Australia, has barely twenty in New Zealand, only one genus, Leptospermum, being typically Australasian. The Proteaceae, which reach their maximum in Australia, with more than 650 species, have only two representatives in New Zealand. There are, however, a considerable number of Epacridaceae, and several Australian genera of orchids, as well as Compositae and Leguminosae. It has been suggested, however, that some of these forms might be of New Zealand origin and migrants into Australia.

Most of the ferns common to the two countries are widespread Australian-Malayan species, but mention should be made of one, *viz., Todea barbara,* common to northern New Zealand and New South Wales and also found in South Africa.

The Fuegian genera already referred to are mostly shared by Australia and New Zealand. Of these there are twenty-two genera common to the two countries, among which may be mentioned Astelia, Muehlenbeckia, Drimys, Nertera and the evergreen beeches, Nothofagus.[4]

There are sufficient resemblances between the floras of Australia and South Africa to indicate some former land connections between the two, but it is probable that the connection was severed at a very remote period.

In South Africa, as in Australia, there is a remarkable development of Proteaceae, but there are no genera common to the two, indicating a very long period of separation. The true heaths (Ericaceae) which are a marked feature of the South African flora are replaced in Australia by the Epacridaceae. It has been suggested[5] that the two families are offshoots of a common stock, differentiated since the disappearance of a former land connection.

It is pretty well agreed that at one time all the great southern land masses were connected more or less completely. The name "Gondwana Land" has been given to an assumed great southern continent, existing in late Permian time, and embracing a large part of the present South American, African and Australian continents, as well as parts of India and Malaya. Just how long these connections remained is not entirely clear, but if they persisted into the Cretaceous, or early Tertiary, this would explain many of the apparently anomalous facts of the present distribution of the floras of the southern hemisphere.

We have also to take into account the great antarctic continent. At present this is practically destitute of any terrestrial vegetation, but there have been found fossils indicating the former presence of a vegetation related to that of South America and New Zealand. Further investigation may show that there was a northward extension of the present antarctic continent, with climatic conditions much more favorable for vegetation, than exists at present.

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[4] Cockayne, *loc. cit.,* p. 206.

[5] Maiden, *loc. cit.,* p. 181.

If further discoveries of fossils should show that, as in the northern hemisphere during the Tertiary, there was also in the south a practically uniform flora encircling the globe, this would make comprehensible both the resemblances and differences now existing in the floras of the southern land-masses.

Migrants from this common southern flora later completely shut off in the present widely separated countries, would in course of time show greater or less divergence from each other, depending upon the amount of change in their environment. It might be expected that in the cool humid climate of New Zealand, the evolution of the primordial southern types would be very different from those subjected to the hot and arid conditions of Western Australia, which is supposed to be the birthplace of most of the strictly Australian plant-types.